2.2 Alcohols, Carboxylic Acids, and Esters

In Lesson 2.1 you briefly studied Earth's ozone layer and its ability to absorb harmful wavelengths of ultraviolet radiation. Concerns about the thinning ozone layer and the possibility of developing skin cancer have more people thinking about using sunscreens to protect themselves from the Sun. All sunscreens contain substances that absorb UV radiation; but with so many products to choose from, which is the best choice?

You may know someone who has an allergy to a certain brand of sunscreen or even to antibiotics prescribed to fight a bacterial infection. Exposure to certain chemical substances can cause an allergic reaction. In Unit A you discovered that the body's immune system responds to antigens, the chemical substances the body identifies as foreign.

What causes substances with such different purposes to have a similar effect on the body? In this lesson you will learn more about the structure of three groups of organic compounds: alcohols, carboxylic acids, and esters. You will identify these molecules by their functional groups, and you will identify some of the chemical and physical properties demonstrated by these groups of compounds.

Alcohols

It was a nasty cold snap. In fact, it was ten straight days of temperatures below –20°C. Although you saw many stalled cars on your way to school, your family's car seemed to start just fine. It may surprise you to know that one of the reasons your family's car was able to continue to operate despite the cold conditions was the addition of a few millilitres of a certain alcohol when the car was last filled up with gasoline.

Figure B2.15: Methanol, a component of gas-line antifreeze, can be used to prevent the formation of ice in the fuel line to an automobile's engine.

Alcohols are a group of organic molecules that possess a **hydroxyl functional group**. Although the hydroxyl functional group consists of two atoms, it replaces a single hydrogen atom on a carbon atom. As you may have noticed, alcohols are also indicated by the suffix *-ol* in their names. Alcohols are one of the most important classes of organic molecules and have many uses.

hydroxyl functional group: a chemical structure found in organic molecules that consists of an oxygen atom bonded to a hydrogen atom; often represented as R–OH, where R represents a hydrocarbon or an organic molecule

SOME ALCOHOLS AND THEIR USES

Example	Use
methanol	solvents, fuels, production of pharmaceuticals, disinfectants
ethanol	solvents, fuels, alcoholic beverages, production of pharmaceuticals, disinfectants
glycol	solvents
isopropanol	disinfectants

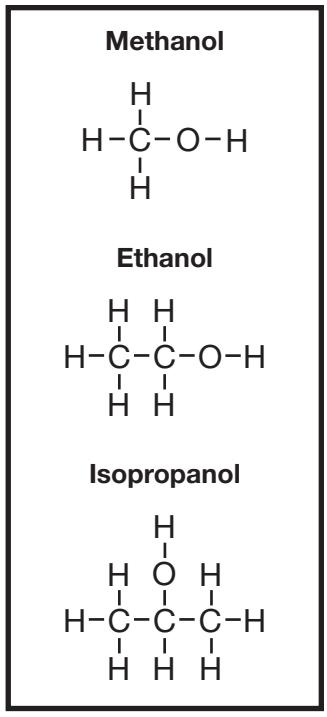


Figure B2.16

Earlier, you learned that hydrocarbons have very low solubility in water. The presence of a hydroxyl group on a hydrocarbon increases the compound's solubility in water. You also learned that the solubility of substances in water is a result of their ability to attract water molecules. In gas-line antifreeze, the polarity of the hydroxyl group of methanol acts to attract water molecules present in the fuel or within the fuel system. The attraction of the water to the methanol molecule prevents the formation of ice, which can block the fuel line.

Nomenclature of Alcohols

The systematic naming of alcohols involves the use of the suffix *-ol* to indicate the hydroxyl functional group. Other parts of the name that precede the functional group can include numbers to describe the position of the hydroxyl group and/or the prefixes and numbers used in naming the hydrocarbon portion of the molecule.

To determine the systematic name for an alcohol, use the following steps. The end result will be to name the hydrocarbon part of the molecule followed by the suffix *-ol* that identifies the hydroxyl group and its location. Alcohols, such as methanol and ethanol shown in Figure B2.16, contain a single hydroxyl functional group located on the first carbon in the parent chain. When the hydroxyl group is in this position, the number 1 is not required.

step 1: Find the hydroxyl functional group on the molecule and circle it.

step 2: Determine the parent chain of carbon atoms, starting at the end nearest the hydroxyl group.

step 3: Use the method of naming hydrocarbons to determine the initial part of the name.

For example, if the parent chain contains two carbon atoms, the initial part of the name will be *ethan-*.

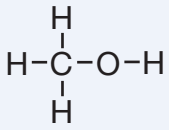
step 4: Communicate the location of the hydroxyl group on the parent chain, and add the suffix that represents the presence of a hydroxyl group.

For example, *2-ol* means the hydroxyl group is on carbon 2. Also, *1,2-diol* means there are two hydroxyl groups: one on carbon 1 and one on carbon 2 of the parent chain.

Example Problem 2.4

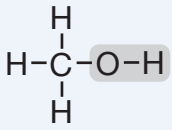
Gas-line antifreeze contains what is sometimes referred to as methyl alcohol or wood alcohol (shown on the right). Determine the systematic name of this structure.

Methyl Alcohol



Solution

step 1: Find the hydroxyl functional group on the molecule, and circle it.



There is one hydroxyl group.

step 2: Determine the parent chain of carbon atoms, starting at the end nearest the hydroxyl group.

The parent chain consists of 1 carbon.

step 3: Use the method of naming hydrocarbons to determine the initial part of the name.

Because there is only 1 carbon in the parent chain, the initial part of the name is *methan-*.

step 4: Communicate the location of the hydroxyl group on the parent chain, and add the suffix that represents the presence of a hydroxyl group.

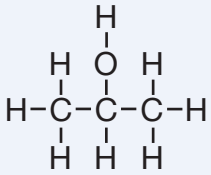
Because there is only 1 hydroxyl group and 1 carbon in the parent chain, add the suffix *-ol*.

Therefore, the systematic name of methyl alcohol, or wood alcohol, is methanol.

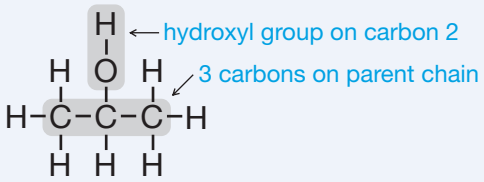
Example Problem 2.5

Isopropyl alcohol is commonly sold in stores as a disinfectant. Use the chemical structure provided to write the systematic name for isopropyl alcohol.

Isopropanol



Solution

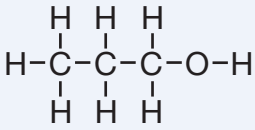


The systematic name of isopropyl alcohol is propan-2-ol.

Example Problem 2.6

Propanol, $CH_3CH_2CH_2OH$, is used as a grease remover in some cleaning products. Draw the chemical structure for propanol.

Solution

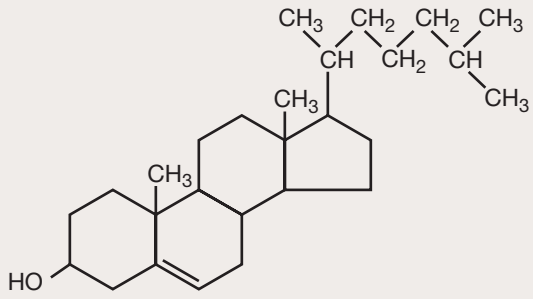


Practice

18. Draw the chemical structure and write the systematic names for two alcohol molecules each containing 3 carbon atoms, 7 hydrogen atoms, and 1 hydroxyl functional group.

19. The accumulation of cholesterol is associated with the blockage of coronary blood vessels that can result in a heart attack.

Cholesterol



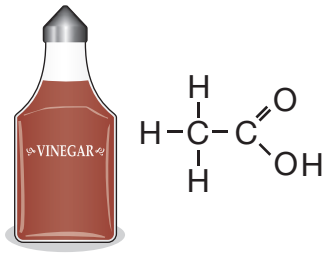
a. Identify the structure on the cholesterol molecule that is similar to alcohols.

b. Identify the portion of the name that identifies cholesterol as a molecule that possesses this functional group.

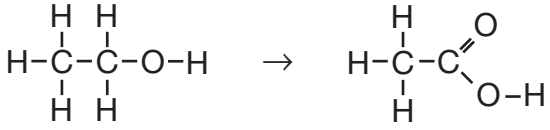
20. Ethan-1,2-diol, also known as ethylene glycol, is a solvent used in the production of paint and is a major component of automobile antifreeze. Use the systematic name to draw the chemical structure for ethylene glycol.

Carboxylic Acids

For many people, vinegar is a welcome ingredient when cooking or seasoning food. From your studies earlier, it may not surprise you that the sour taste of vinegar is due to the presence of an acid. Whether your favourite vinegar is balsamic, malt, or white, the tangy taste is due to the presence of ethanoic acid. Ethanoic acid is produced naturally by the conversion of ethanol by certain kinds of bacteria. Ethanol-containing substances, like wine and cider, have been used for centuries to make many kinds of vinegars.



The Conversion of an Alcohol to a Carboxylic Acid



Ethanol **Ethanoic Acid**

Figure B2.17: The functional groups for the reactant and product show that oxygen has a significant role in this reaction.

Carboxyl Functional Group

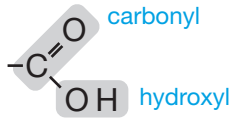


Figure B2.18: The carboxyl functional group is the combination of two functional groups: a carbonyl functional group and a hydroxyl functional group.

The **carboxyl functional group** contains two oxygen atoms joined to the same carbon atom. By examining Figure B2.18, you will notice that the carbon atom in the carboxyl group is attached to a single oxygen atom by a double bond; this is the **carbonyl functional group**. This same carbon is also attached to the oxygen of a hydroxyl group. All carboxylic acids contain this combination of functional groups, often represented as R-COOH and with the suffix *-oic acid* in their names.

carboxyl functional group: the organic chemical structure composed of a carbonyl functional group and a hydroxyl functional group chemically joined to the same carbon atom

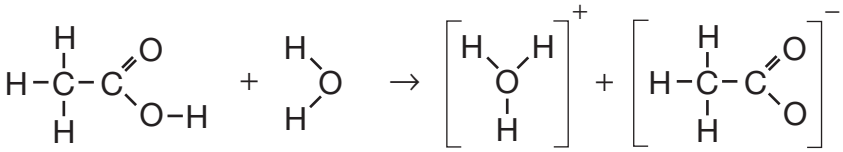
carbonyl functional group: the functional group formed by the joining of an oxygen atom to a carbon atom by a double bond

In Chapter 1 you examined the empirical properties of acids and discovered that acids undergo a reaction with water that produces hydronium ions. Carboxylic acids demonstrate the same empirical properties as other acids. Hydronium ions are produced by the reaction between the hydrogen located on the hydroxyl group and water.

Ethanoic Acid Reacting with Water

$$CH_3COOH(aq) + H_2O(l) \rightarrow H_3O^+(aq) + CH_3COO^-(aq)$$

acid — base — conjugate acid — conjugate base



In an earlier investigation, you tested the conductivity and pH of ethanoic acid and hydrochloric acid solutions with identical concentration. It was discovered that the ethanoic acid solution had a lower conductivity and a higher pH compared to the hydrochloric acid solution. This is because organic acids do not react completely with water and, thus, are categorized as weak acids.

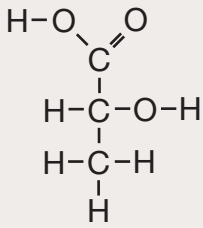
Lactic acid is the common name for a carboxylic acid produced by the body during physical exertion. Strenuous exercise usually results in the accumulation of lactic acid inside muscle cells. The fatigue you experience while exercising is often due to the accumulation of hydronium ions—resulting in a small change in the pH within your muscles—produced by the reaction of lactic acid with water. If lactic acid were a strong acid, a greater change in pH would occur within your muscle cells.

How does the body respond to changes in pH within its cells? As you know, humans, as well as all organisms, do not respond well to large changes in pH. Cells, as well as the blood, contain substances to neutralize excess hydronium ions. Hydrogen phosphate ions and dihydrogen phosphate ions present in muscle cells act as a buffering system to maintain a relatively constant pH within muscle cells even during physical exertion.

Practice

21. Copy the structure of lactic acid into your notebook.

Lactic Acid



a. Use differently coloured pens or pencils to draw circles that identify the hydroxyl, carbonyl, and carboxyl functional groups.

b. Use a balanced chemical equation to show how the reaction between lactic acid and water produces a hydronium ion.

c. Explain how the presence of hydrogen phosphate or dihydrogen phosphate could act to buffer the accumulation of hydronium ions that occurs during strenuous exercise.

Some Chemical Structures That Cause Allergic Reactions

Previously, you learned that some people have concerns about the substances present in sunscreens. PABA, short for para-aminobenzoic acid, is a molecule formed by the attachment of two functional groups—one being a carboxyl group—to a benzene molecule. The chemically stable benzene ring is able to absorb UV radiation, serving to protect skin layers beneath the sunscreen. Unfortunately for some people, exposure to PABA causes an allergic reaction. People with sensitivity to PABA tend to be sensitive to other medicines. Some sunburn and sore-throat medications, along with certain antibiotics, can be broken down by the body to produce PABA or a chemical structure very similar to PABA. The body's contact with these compounds triggers the immune system to respond.

For people who are highly sensitive to an antigen, there is a risk that exposure could cause an **anaphylactic reaction**. For some people, the choice of products they use is very important.

anaphylactic reaction: a life-threatening, severe reaction of the immune system to an antigen that results in severe swelling and may affect the muscles involved in breathing

Figure B2.19: People with extreme sensitivity to certain chemical compounds often wear jewellery that informs medical personnel of their allergy.

DID YOU KNOW?

Rashes, itchy skin, or hives can be an indication that your body is having a mild allergic reaction. Swelling and difficulty breathing are often signs of severe allergic reactions and, thus, require immediate medical attention.

Naming Carboxylic Acids

Writing systematic names for carboxylic acids involves similar steps to those used to name alcohols. The end result will be to name the hydrocarbon part of the molecule followed by the suffix *-oic acid*, which identifies the carboxyl group.

Example Problem 2.7

Propanoic acid is used to prevent some foods from spoiling.

a. Use the systematic name to draw the chemical structure for propanoic acid.

b. State whether it is possible to have the carboxyl functional group on the second carbon in the parent chain of propanoic acid.

Solution

a. **propanoic acid**

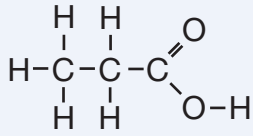
A B C

A indicates that there are 3 carbons in the parent chain

B indicates that the compound is a carboxylic acid—contains a carboxyl functional group

C no number indicates that the carboxyl group is attached to the first carbon

Therefore, the chemical structure is



b. The carboxyl functional group requires three bonds. A carbon atom within a chain has only two bonds available, since two of the four bonds are needed for the adjacent carbon atoms. Therefore, it is not possible for a carboxyl functional group to appear in the middle of the parent chain.

Practice

22. Prepare a table that lists the chemical structures and the systematic names for the carboxylic acids that contain one, two, and three carbons, respectively.

Household Cleaning Products

Many people use vinegar for purposes other than food preparation. Many properties of acids make them ideal for a variety of purposes, but can they be used as cleaning products in your home? In the next activity you will examine the cleaning products used in your home and consider the risks and benefits of using vinegar for cleaning.

Utilizing Technology

Risks and Benefits of Household Cleaning Products

Purpose

You will identify issues associated with the use of common household cleaning products and to evaluate the use of alternative products.

Science Skills

- ✓ Performing and Recording
- ✓ Analyzing and Interpreting
- ✓ Communication and Teamwork

Background Information

Regular household cleaning often involves the use of many products. Apart from the instructions for using the product and the safety information listed on the label, most people are unaware of possible risks associated with **direct exposure** to these products. Concerns also exist regarding whether the substances in household cleaning products are **biodegradable** or whether they will have negative, unexpected effects on the environment.

Problem

Is vinegar a safe and suitable replacement for many liquid household cleaners?

direct exposure: contact with a chemical substance that occurs while using it or by being present in an area where it has been used

biodegradable: ability to be broken down by natural mechanisms

Procedure

step 1: Prepare a list of the liquid cleaning products used during a routine cleaning of your home and the homes of other people in your class. Identify the intended use for each product (glass cleaner, disinfectant, stain remover, etc.). Also, identify the size of the container and the cost of each cleaning product.

step 2: Use the product label, the Internet, and/or other sources of information to identify risks associated with the use of the cleaning products listed. Collect information about the

- safety concerns regarding the storage of the product
- safety concerns when using the product
- harmful effects to humans or pets from direct exposure to the product
- information about the product's biodegradability

step 3: Use the Internet to prepare a list of where vinegar can be used as an appropriate cleaner. Also, indicate situations where it is not recommended to use vinegar as a cleaner.

step 4: Use the product label and/or the Internet to collect information about risks associated with the use of vinegar.

step 5: Determine the quantity of each substance used during a regular household cleaning session. Add this information to the list prepared in step 1.

step 6: If possible, perform an experiment to determine whether vinegar is a suitable replacement for a cleaning product used in your home.

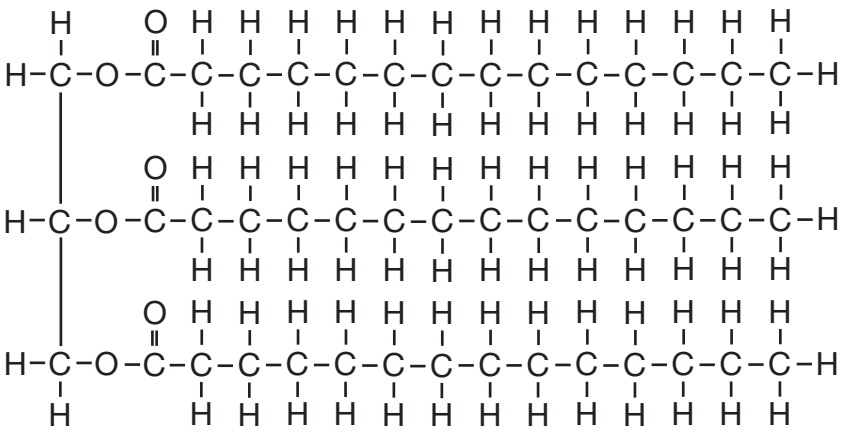
Analysis

1. Identify cleaning products that could be replaced by using vinegar.
2. Calculate a price per millilitre for each liquid cleaning product used during the regular household cleaning session. Calculate the total cost for all the liquid cleaning products used in the cleaning session. You may find it helpful to use a spreadsheet or graphing calculator to calculate and display this information in a table.

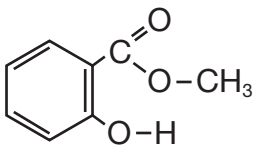
3. Use the information you collected to estimate the quantity of vinegar required to complete the cleaning session. Use resources available to you to determine the cost of using vinegar to complete the routine cleaning session.
4. Prepare a risk-benefit analysis of using vinegar as a replacement for the liquid cleaners.
5. Evaluate the list of risks and benefits you prepared and develop a response to the problem stated at the start of this activity. Use one or more of the following perspectives in supporting your answer: scientific (or technological), ecological, and economic.

Esters

Fat Molecule



Methyl Salicylate

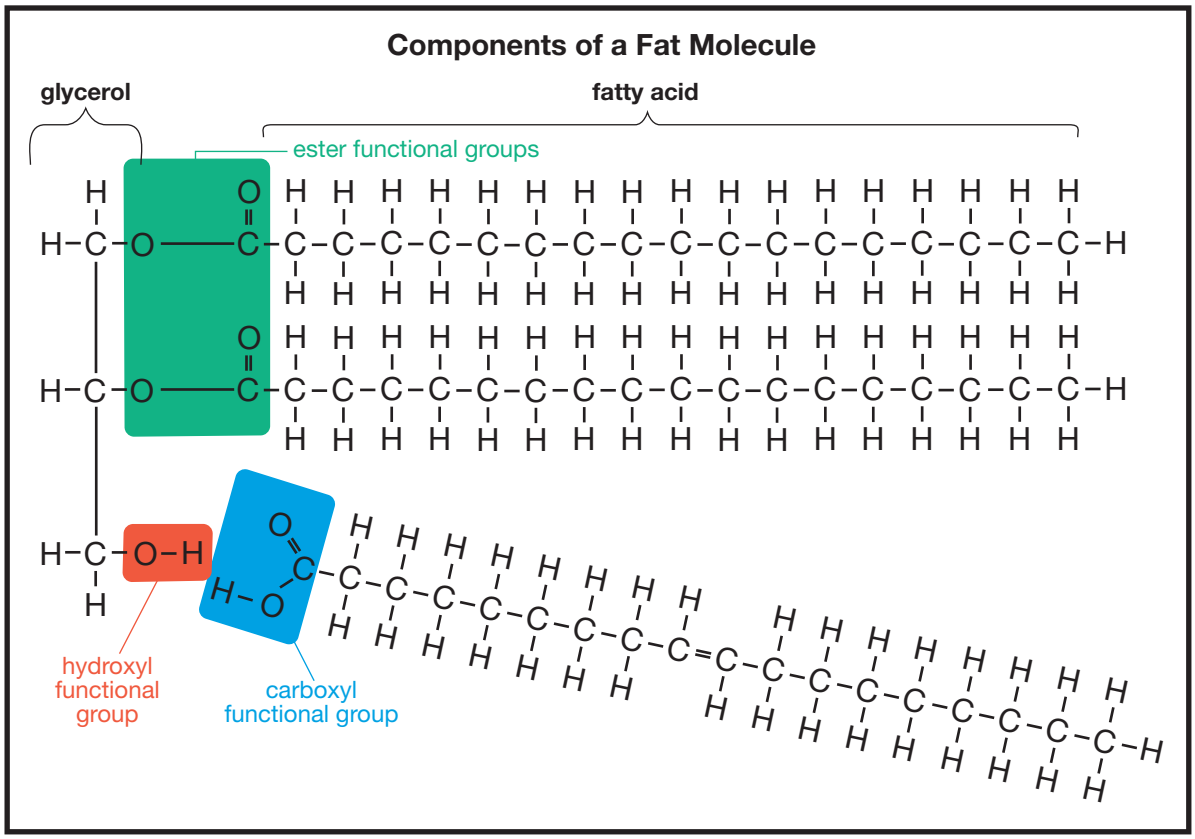


Esters are organic compounds formed by the chemical reaction of a carboxylic acid with an alcohol. Esters may be naturally occurring or synthetic products. In previous science courses you may have heard about fatty acids and fats. Fats and oils are examples of naturally occurring esters produced by your body. The synthesis of fats involves chemically joining three carboxylic acid molecules, called fatty acids, to the hydroxyl groups on a glycerol molecule.

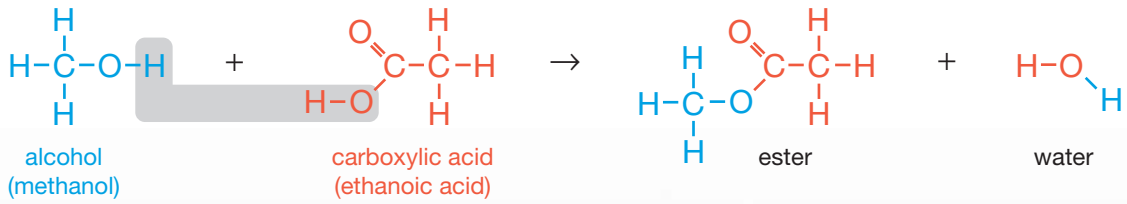
The food and cosmetics industry dedicates a great deal of time to identifying naturally occurring esters and developing synthetic methods to produce these molecules to enhance their taste or aroma.

Figure B2.20: Esters are used to provide a desired flavour or odour to a food product like red licorice.

Structure and Formation of Esters



Esters contain a functional group that is a combination of the functional groups of a carboxylic acid and an alcohol. The reaction that forms an ester also forms a second product: a water molecule. The elimination of the water molecule is necessary to enable the chemical joining of the carboxylic acid to the alcohol.



The reaction that synthesizes an ester occurs between the functional groups, leaving the parent chain of both reactants unaffected. Since the other parts of the reactant molecules are unaffected, the components of an ester can be identified and a systematic process can be used to name esters.

Naming Esters

As you have seen, naming other organic compounds with functional groups containing oxygen involves the use of a suffix that identifies the functional group. For esters, the suffix is *-oate*. The remainder of the name identifies the alcohol and the carboxylic acid used in its synthesis.

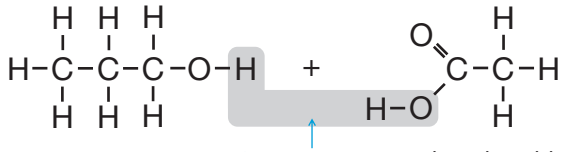
Naming an ester involves either knowing both the alcohol and carboxylic acid used in its synthesis or analyzing its chemical structure to determine these components.

Example Problem 2.8

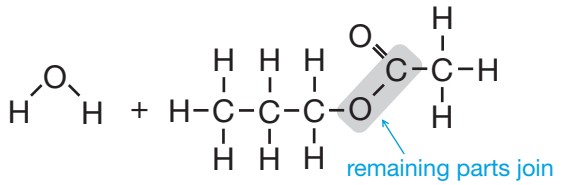
A chemical reaction occurs between propanol and ethanoic acid. Use a structural diagram to show the reactants and products for this reaction.

Solution

Reactants



Products



To determine the systematic name for an ester from a structural diagram, use the following steps:

step 1: Find the ester functional group, and draw a box around it. Then circle each chain of carbon atoms that extend from the functional group.

step 2: Locate the chain of carbon atoms that is attached to the functional group by a single bond to an oxygen atom.

This is the part of the molecule derived from an alcohol.

step 3: Identify the number of carbons in this chain.

If the chain contains one carbon, the prefix *methyl* is used.

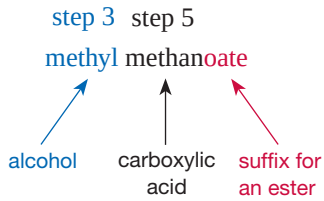
step 4: Count the number of carbon atoms in the chain, starting with the carbon that contains a double bond to an oxygen atom.

This is the portion of the ester that is derived from a carboxylic acid.

step 5: Identify the number of carbons in this chain.

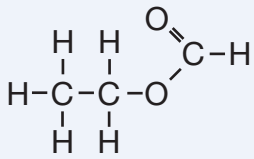
For example if the chain contains one carbon, *methan-* is used in this part.

step 6: List the parts identified in steps 3 and 5, followed by the suffix *-oate*.



Example Problem 2.9

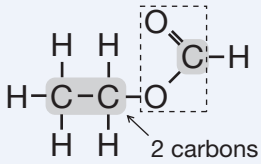
The ester depicted here produces an aroma similar to that of raspberries. Write the systematic name for this ester.



Solution

Follow the steps of systematically naming an ester. First, isolate the three parts of the ester; then identify the alcohol part of the name (steps 1 to 3).

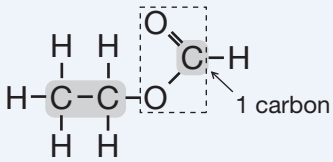
Steps 1 to 3



Since there are 2 carbons in the alcohol part, the first part of the name of this ester is *ethyl*.

Now, identify the carboxylic acid part of the name (steps 4 and 5).

Steps 4 and 5



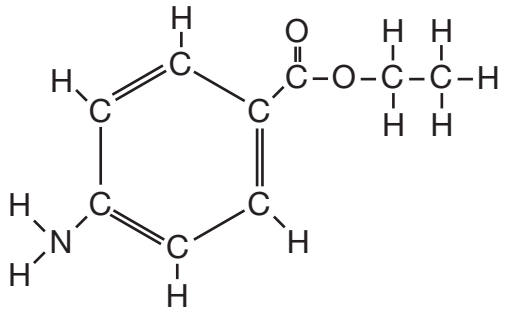
Since there is only 1 carbon in the carboxylic acid part, the middle part of the name of this ester is *methan-*.

Therefore, when you add the suffix *-oate* (step 6) for an ester, the systematic name of this ester is ethyl methanoate.

Practice

23. Benzocaine is an organic compound that is able to dull the sensation of pain by acting on parts of the nervous system. Benzocaine is used in a variety of products, including lotions and ointments used to treat mouth sores, insect bites, and sunburns.

Benzocaine



a. Copy the structure of benzocaine into your notebook, and draw a box around the ester functional group.

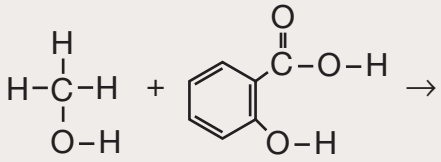
b. Circle and label the part of the benzocaine molecule that is derived from an alcohol and the part that is derived from a carboxylic acid.

c. State the name of the alcohol used in the production of benzocaine.

d. Explain why people who have allergies to sunscreens containing PABA may also demonstrate a sensitivity to benzocaine.

24. Draw the structural diagrams for the products of the following reactions. Where possible, write the names for the chemical substances involved.

a.



methanol salicylic acid

b. $CH_3CH_2OH(l) + HCOOH(l) \rightarrow$

c. ethanol + ethanoic acid $\rightarrow$

DID YOU KNOW?

Acetylcholine—an important molecule in the action of nerves—is an ester. The ester group of an acetylcholine molecule is continually broken apart and reformed as nerve cells function to recycle this important molecule.

Investigation

Making Esters

Purpose

You will prepare a synthetic, organic compound—an ester.

Science Skills

✓ Performing and Recording

Pre-Lab Activity

Obtain the handout "Making Esters" from the Science 30 Textbook CD, and closely study the table to see which scents are produced from the reaction of the carboxylic acid and the alcohol. Also, obtain from your teacher a list of the alcohols and carboxylic acids available to you for this investigation.

1. Write the reactions and expected results for three esters that can be synthesized using the alcohols and carboxylic acids available to you. Determine the systematic name for each ester. Show your reactions to your teacher.

Materials

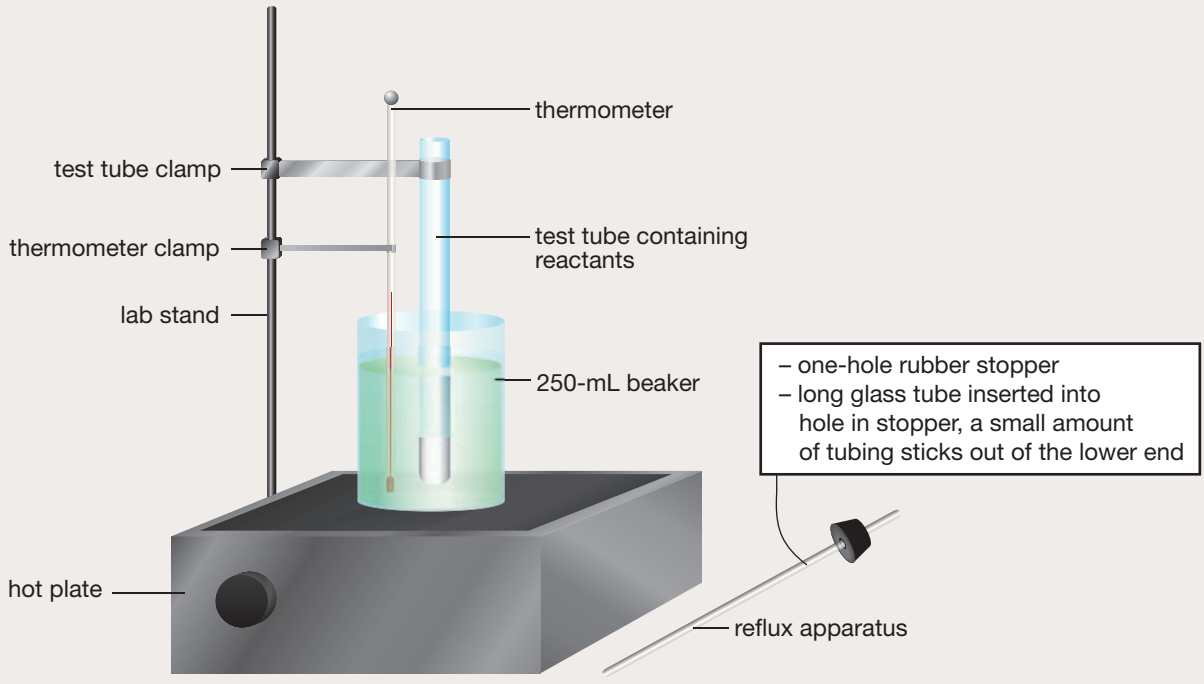
- tap water
- 25 mm × 250 mm test tubes (or larger) (1 for each reaction)
- 2, 250-mL beakers
- 3, 10-mL graduated cylinders
- weighing boat
- lab stand
- test tube clamp (or utility clamp)
- reflux apparatus (one-hole stopper with inserted glass tubing)
- alcohols and carboxylic acids made available by your teacher
- dropper bottle containing concentrated sulfuric acid (handled only by your teacher)
- hot plate
- thermometer
- thermometer clamp
- laboratory tongs
- laboratory scoop
- electronic balance
- a vial of salicylic acid
- evaporating dish (1 per reaction)
- test tube rack
- tray or large beaker containing ice

CAUTION!

Use gloves, safety glasses, and a lab apron for this activity. Sulfuric acid is corrosive; use extreme caution.

Procedure

step 1: Assemble a water bath by placing a 250-mL beaker, half-filled with tap water, onto the hot plate. Place the water bath close to the lab stand. Attach the thermometer clamp to the lab stand and position the thermometer inside the clamp in such a way that it measures the temperature of the water inside the water bath. Attach the test tube clamp to the lab stand.



step 2: Transfer approximately 4 mL of the carboxylic acid you have chosen and approximately 5 mL of the alcohol you have selected into separate graduate cylinders. **Note:** If you use salicylic acid, measure approximately 2 g of the salicylic acid crystals into a weighing boat.

step 3: Transfer the contents from the graduated cylinders to the test tube. Fasten the test tube to the test tube clamp attached to the lab stand in such a way that the reactants in the test tube are below the surface of the water bath.

step 4: Use a clean graduated cylinder to measure 2 mL of concentrated sulfuric acid. Add this to the contents of the test tube.

step 5: Attach the reflux apparatus to the test tube. Turn on the hot plate, and begin heating the water bath. Monitor the temperature of the water bath during the experiment to maintain the temperature of the water bath between 70°C and 80°C. Allow the contents of the test tube to heat for 15 min.

step 6: Remove the test tube from the water bath, and allow the contents to cool for 5 min; then place the test tube into a second water bath containing cold or ice water water for 5 min.

step 7: Pour the cooled contents into an evaporating dish. Gently waft the vapour from the dish containing the synthesized ester toward you. Record the odour detected in the appropriate place in your table.

step 8: Repeat steps 2 to 7 for your two other esters.

step 9: Follow your teacher's instructions regarding the disposal of liquid waste. **Be careful not to spill or splash the esters. These mixtures may contain unreacted sulfuric acid.**

step 10: Disassemble, wash (if needed), and return the equipment to its appropriate place.

Analysis

2. Compare the observed odours with the scents listed in the "Making Esters" handout. Were you able to create the ester you intended to synthesize? Use the evidence from the experiment to support your answer.
3. Compare your results with those of other students in your class. Were some esters more difficult to make than others?
4. Is the creation of an ester a fast or slow reaction? Give a reason for your answer.
5. Is this method to create esters reliable and valid?

Polyesters

Enjoying the outdoors may require more than just sunscreen. The pieces of equipment used by wakeboarders, for example, are composed of many different kinds of **plastics**. Most plastics in manufactured materials are **polymers**. One common type of plastic is **polyester**. It is created from the reaction of many alcohols and carboxylic acids, forming long chains or filaments. These filaments are used to make such things as towropes, straps for personal flotation devices (PFDs), and some of the everyday T-shirts in your dresser.

- **plastic:** material that can be shaped or moulded with or without the application of heat
- **polymer:** a large molecule formed by the chemical joining of many smaller molecules
- **polyester:** a polymer containing many ester functional groups

To form the long chains of ester bonds, both the carboxylic acid and alcohol must have two functional groups. For these molecules, chemical reactions occur at both functional groups. This enables the molecule to grow in both directions, producing a filament. Bonding that occurs within and between filaments is responsible for the strength of the plastic, making polyesters like Dacron a useful material in many applications.

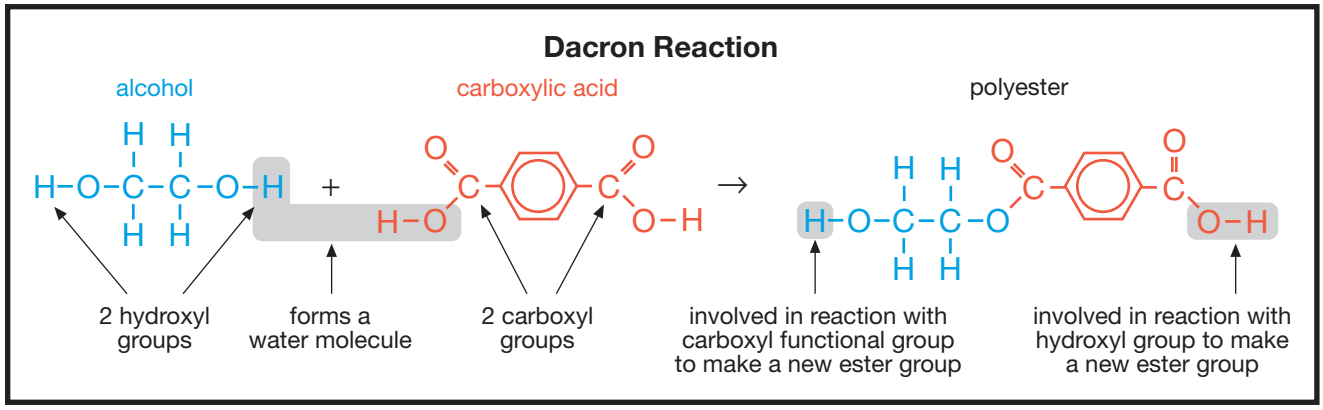


Figure B2.21: A common polyester, called Dacron, is formed by the reaction of an acid and an alcohol, each with two functional groups.

Bioplastics

A major problem with the use of plastics is that they are not biodegradable. Although recycling is one way of reducing the amount of waste sent to landfills, many plastics used today that make their way to landfills will not break down.

bioplastic: an organic polymer produced by plants or bacteria that can be used in place of synthetic polymers to form materials

Bioplastics are a group of compounds that can be used to produce a wide range of materials and have the added advantage of being completely biodegradable. Plastic cups, cutlery, plates, and store bags may be formed from a variety of naturally produced compounds. Bioplastics are produced by extracting a polyester compound from the tissues of plants (such as corn, soy, and even hemp) or from the cells of certain bacteria. The naturally occurring compounds used as bioplastics can be decomposed by bacteria within the soil, often within a few months if properly disposed. Bioplastics are being considered for use in materials like dissolvable sutures and other medical applications.

Utilizing Technology

Bioplastics

Question

How do products made from bioplastics compare to the same products made from synthetic plastics?

Researching the Issue

Use the Internet to prepare a list of different types of bioplastics. For each type of bioplastic, list products that are made from that bioplastic.

Science Skills

- ✓ Performing and Recording
- ✓ Analyzing and Interpreting
- ✓ Communication and Teamwork

Choose one product made from bioplastic, and design a series of experiments that will compare the properties of the product formed from the bioplastic to the same product formed from a synthetic plastic. Show your teacher the designs for the experiments you wish to conduct. If possible, perform the experiments. Use the data collected from your experiments and the results from your research to demonstrate the uses of materials composed from bioplastics.

2.2 Summary

In this lesson you studied organic compounds that have functional groups containing oxygen atoms. Alcohols, carboxylic acids, and esters represent three important groups of compounds that can be identified by the suffixes in their respective systematic names. Compounds within these groups have significance in biological systems and are often used in all aspects of people's lives, including food, building materials, and manufactured products.

2.2 Questions

Knowledge

1. Complete the following table.

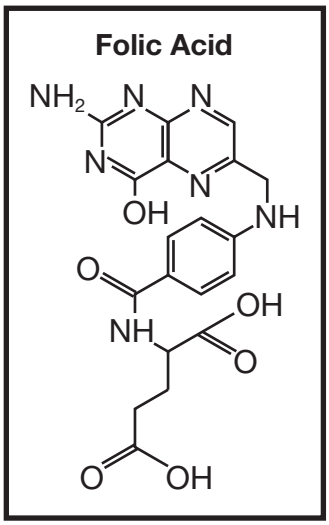
Type of Organic Compound	Drawing of Functional Group	Name of Functional Group	Suffix Used During Naming
alcohol			
carboxylic acid			
ester			

2. Prepare a list of some of the common uses for alcohols, carboxylic acids, and esters.

3. State the empirical properties shared by all acids, including carboxylic acids.

Applying Concepts

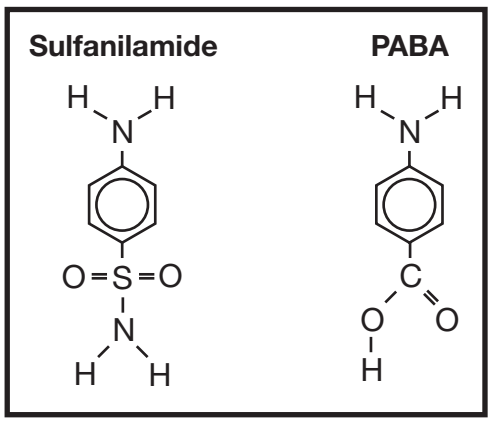
4. Folic acid is one of the B vitamins essential to human health. People must obtain folic acid through their diet. Bacteria are able to produce folic acid when provided PABA (para-aminobenzoic acid).



a. Identify the hydroxyl functional groups present in the structure of folic acid.

b. Identify the carboxyl functional groups present in the structure of folic acid.

5. Sulfanilamide is an antibiotic used to treat bacterial infections. Doctors must check their records to ensure that patients do not have an allergy to PABA before prescribing sulfanilamide.

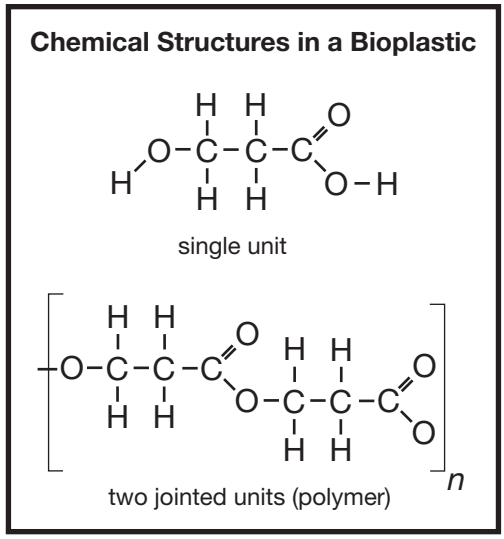


a. Identify similarities between the chemical structures of sulfanilamide and PABA.

b. Explain the significance of any similarities in structure between these two compounds and its importance to a patient's treatment.

c. Explain why it is important for doctors to know about a patient's sensitivity to PABA, or other compounds, when prescribing drugs.

6. The chemical structures for a type of bioplastic are shown here. The first structure represents a single unit, and the other represents two joined units that form part of the polymer. Use these diagrams to answer the following questions.



a. Copy the chemical structure for the single unit into your notebook. Circle each functional group, and identify the name.

b. Identify the type of functional group in the polymer.

c. Use structural diagrams to explain how the polymer can be formed from the combination of two single-unit molecules.

d. Use structural diagrams to show the polymer formed from the combination of four single-unit molecules.

e. Write the balanced chemical equation for the process explained in question 6.d.